

# Search for Associated Production of $Z$ and Higgs Bosons in $e^+e^- b\bar{b}$ Final States with the DO Detector



- Tevatron Status
- DO Detector
- SM Higgs
- $Z(ee) + \text{Jets Analysis}$
- Summary



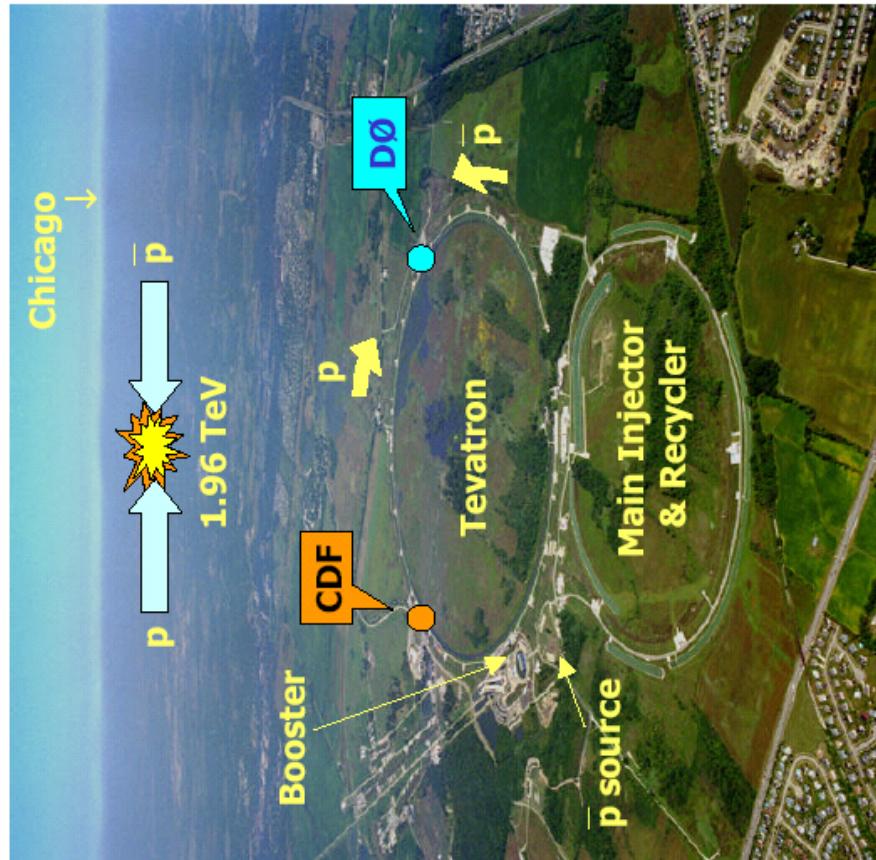
Marc Buehler, UIC

APS Denver - 2 May 2004 1

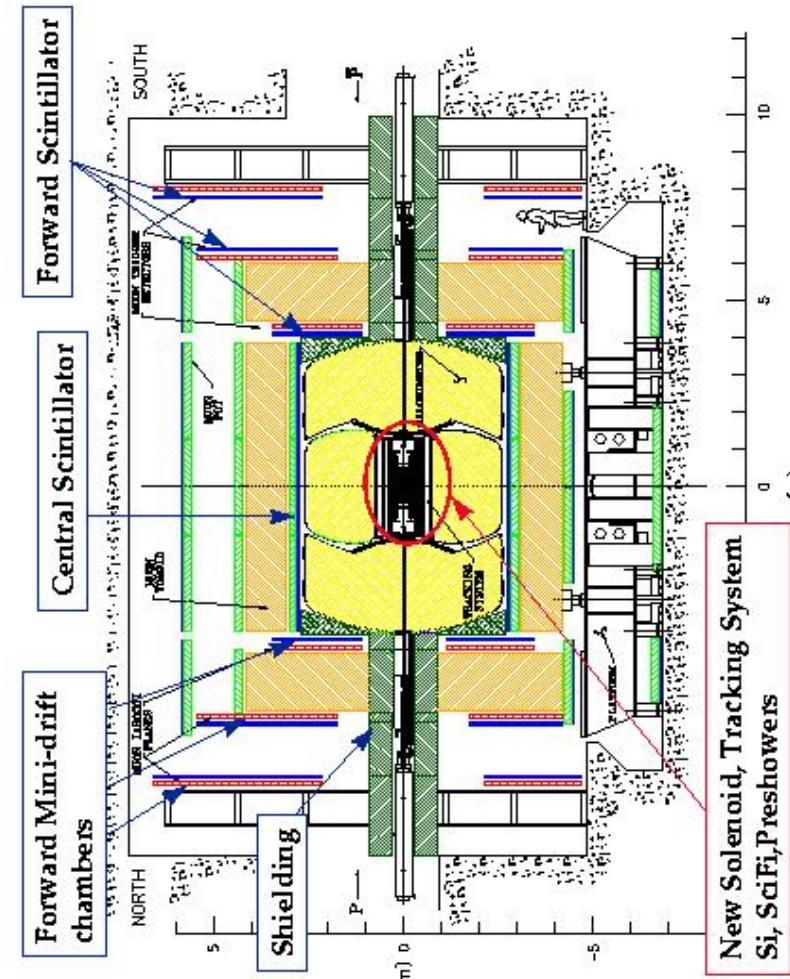
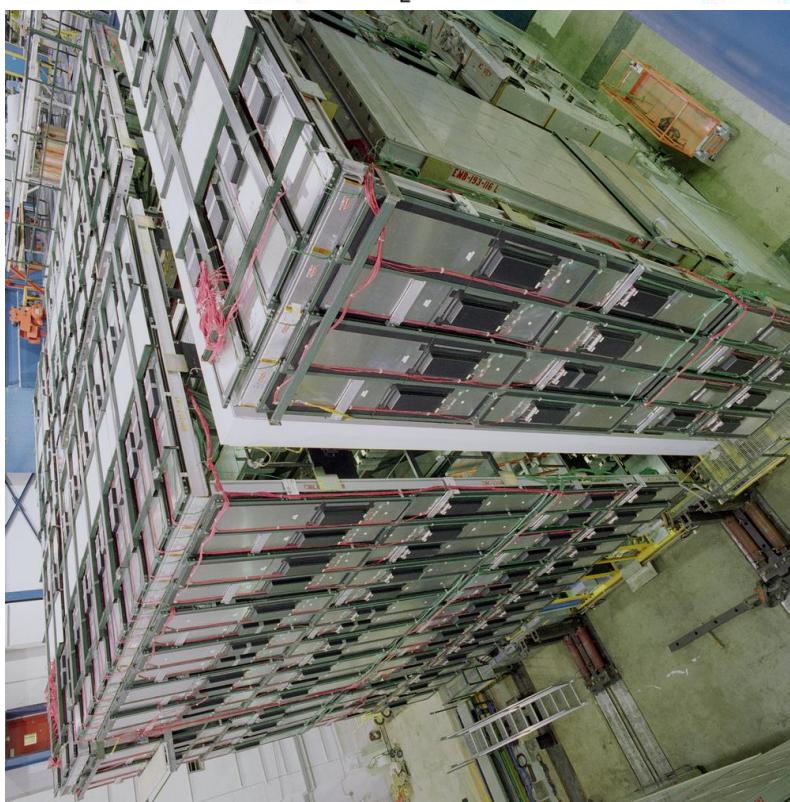
# Tevatron Collider in Run II



- Colliding protons and antiprotons at  $\sqrt{s}=1.96\text{ TeV}$  (Run I:  $1.8\text{ TeV}$ )
- $36 \times 36$  proton and antiproton bunches with  $396\text{ ns}$  bunch crossing time (RunI:  $6 \times 6 / 3.5\text{ }\mu\text{s}$ )
- Increased instantaneous luminosity (currently  $4\text{--}5 \times 10^{31}\text{ cm}^{-2}\text{ s}^{-1}$ )
- Run II goal for total integrated luminosity  $1\text{--}2\text{ fb}^{-1}$  by LHC turn-on (2007)

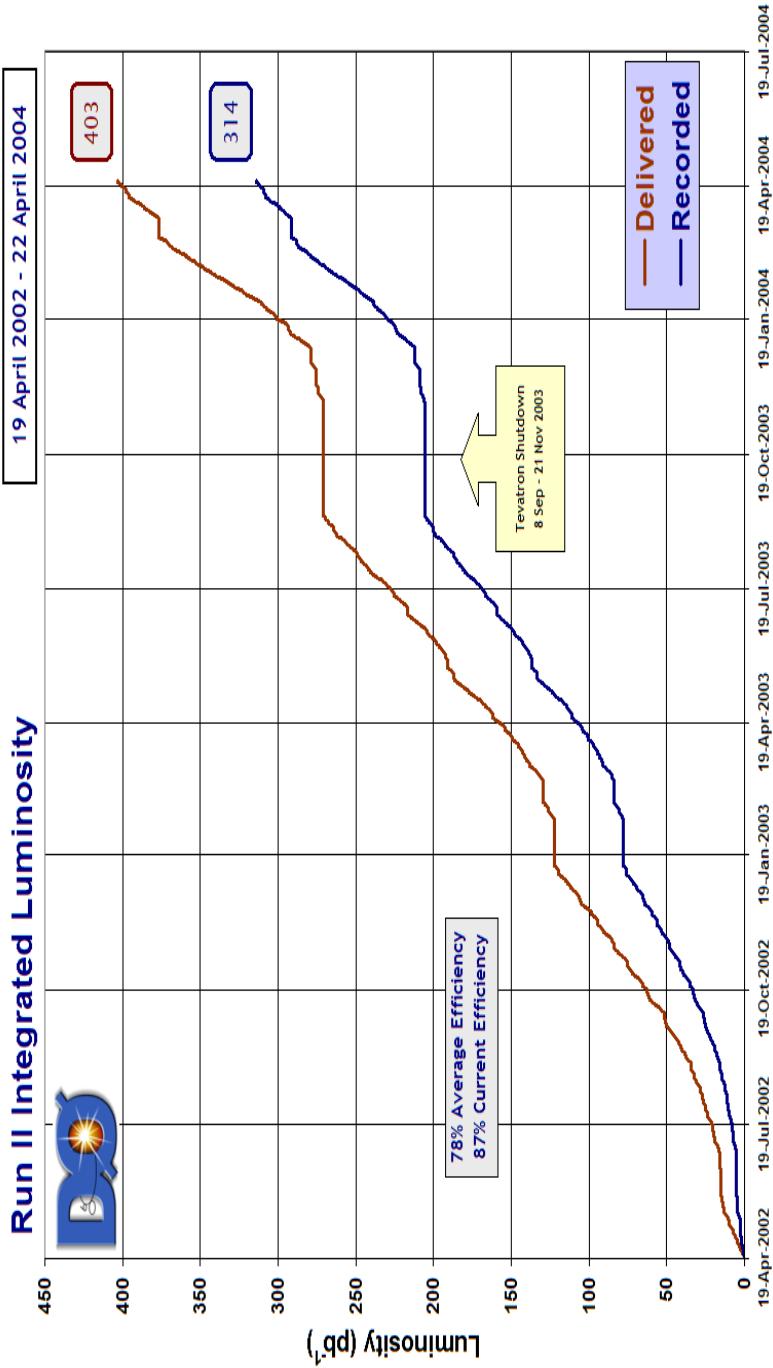


# The upgraded DO Detector



- New tracking: silicon and fibers in 2T magnetic field
- Upgraded muon system
- Upgraded DAQ/trigger (displaced-vtx trigger soon !)

# DO Data Taking



Run I =  $166\text{pb}^{-1}$  delivered /  $130\text{pb}^{-1}$  recorded

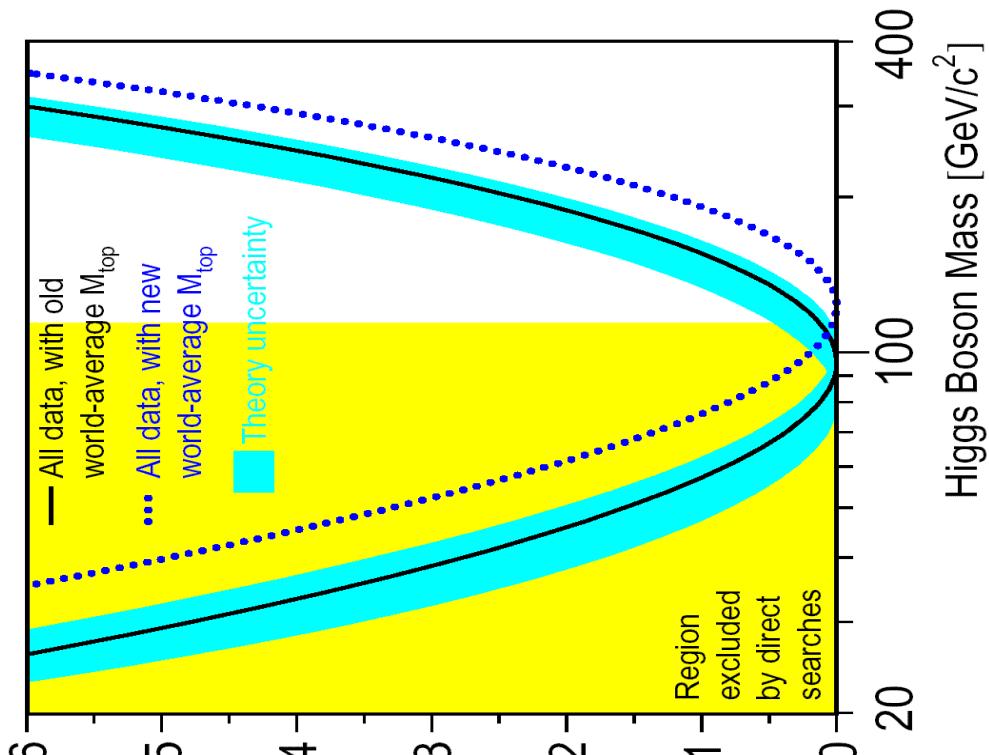
Integrated luminosity for this analysis:

- $170\text{pb}^{-1}$  (up till Oct 03 shutdown)
- $250\text{pb}^{-1}$  (including data taken after Oct 03 shutdown)

# The SM Higgs in a Nutshell



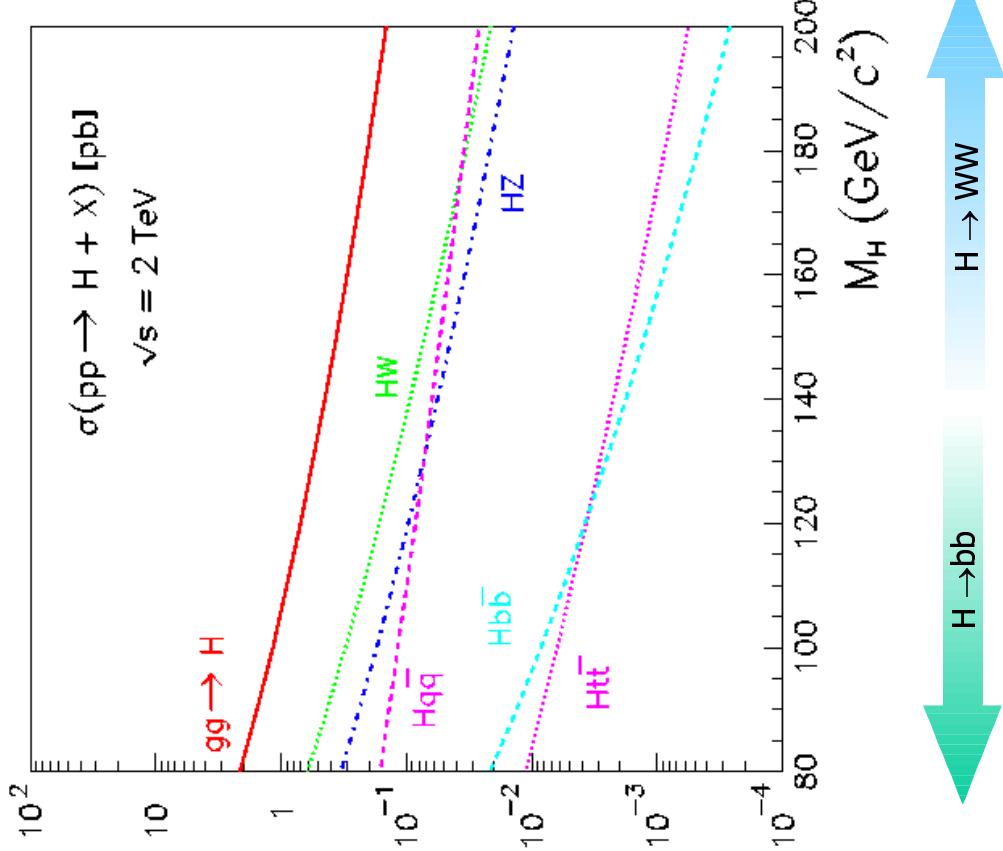
- Last missing piece of the SM
- Explains electroweak symmetry breaking
- Gives masses to fermions and quarks
- Light SM Higgs preferred:
  - $M_H = 117 \text{ GeV}$ ,  
 $M_H < 251 \text{ GeV} @ 95\% CL$
  - LEP's direct search:  
 $M_H > 114.4 \text{ GeV} @ 95\% CL$



# Higgs Search Strategy



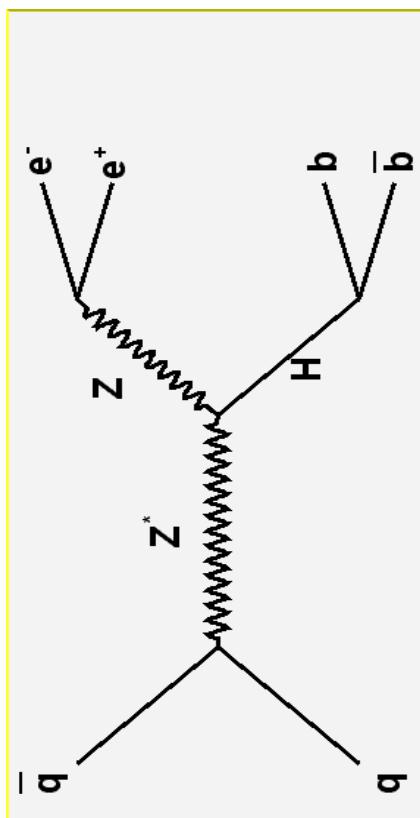
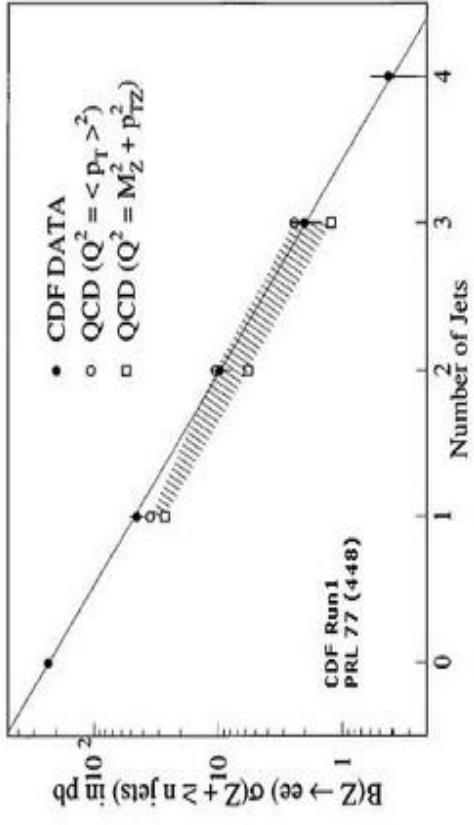
- Production cross sections are small depending on Higgs mass (.1-1 pb)
- $H \rightarrow bb$  dominant for  $M_H < 140$  GeV
  - Searches can be performed in  $W/Z$  associated production to handle backgrounds
  - $H \rightarrow WW$  final states can be explored at higher masses
  - Need fb datasets to find the Higgs !!!



# Z( $ee$ ) + Jets Analysis



- Too early to go "Bump Hunting" !!!
- This analysis is going to measure the Z( $ee$ ) + Jets production cross section:
  - Determination of the reliability of QCD calculations for heavy boson production
  - Testing the theoretical predictions of cross sections
  - Study the production properties of high energy hadronic jets associated with Z boson production

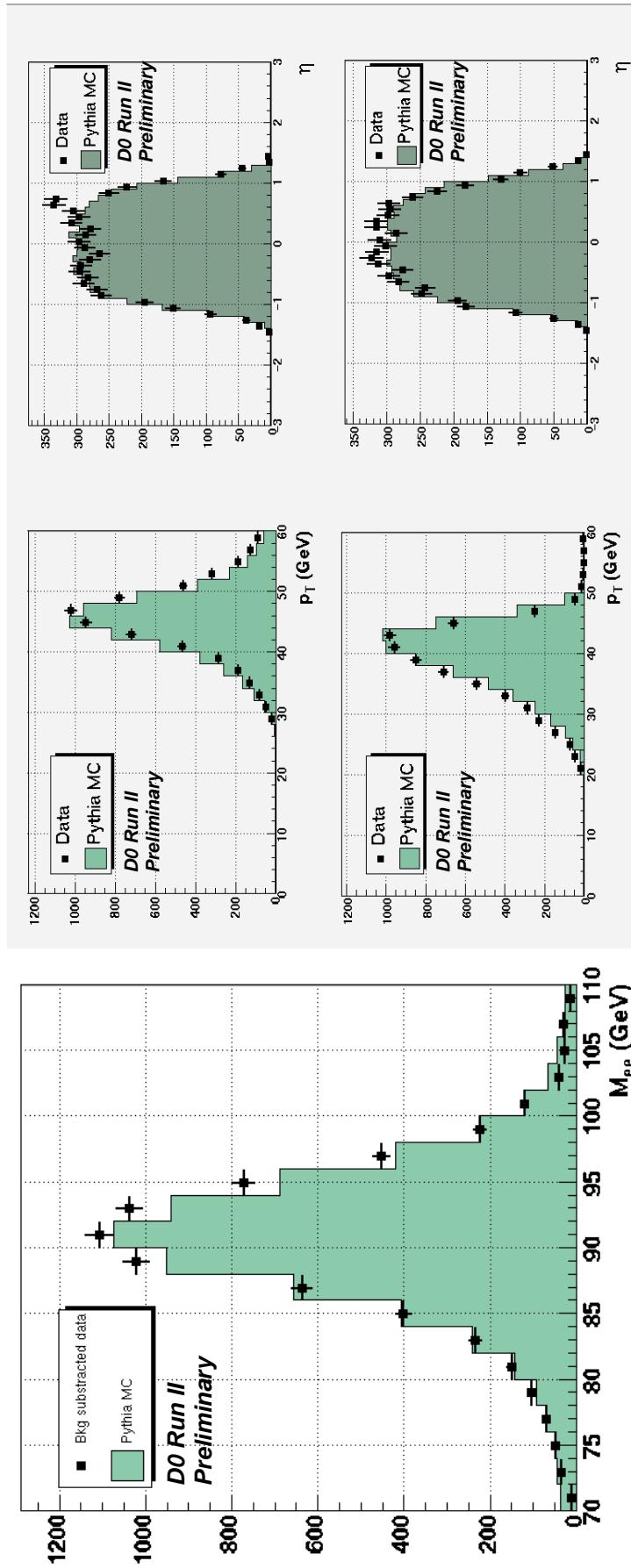


- Event selection includes:
  - 2 central and isolated electrons with  $p_T > 20 \text{ GeV}$  and at least one track match
  - DiEM invariant mass cut:  $80 \text{ GeV} < M_{ee} < 100 \text{ GeV}$
  - Jet Energy Scale corrected Jets with  $p_T > 20 \text{ GeV}$  passing all jet quality cuts

# Electron Distributions in Z Events

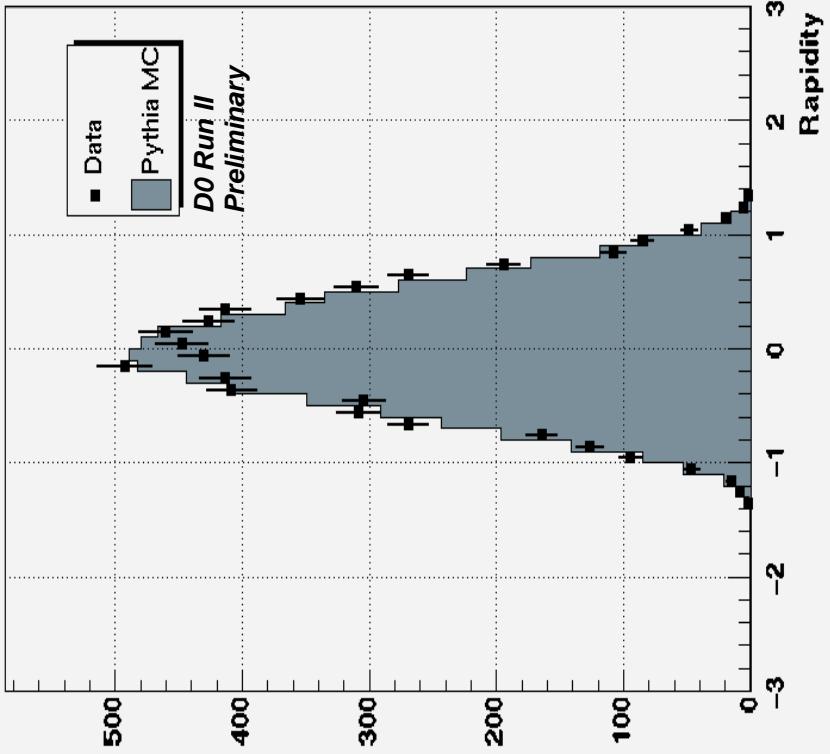
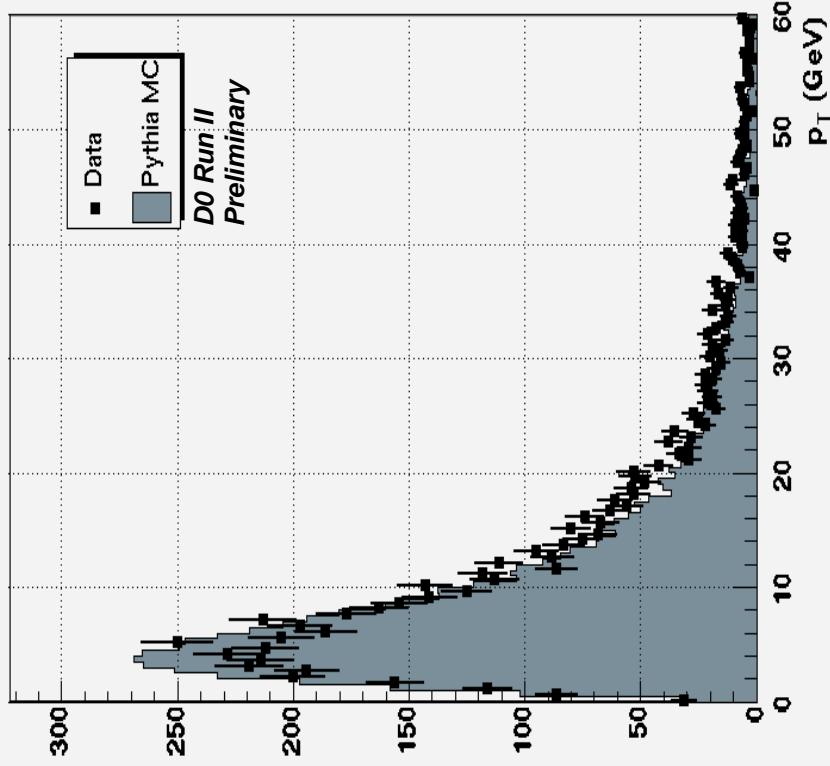


- Points represent data with statistical errors - histograms represent Pythia MC & GEANT detector simulation
- Approximately 6,000 Z candidate events in  $170\text{pb}^{-1}$  of data



- DiEM invariant mass distribution
- Transverse momentum and  $\eta$  distributions for leading and second leading electron in Z events

# Z Properties

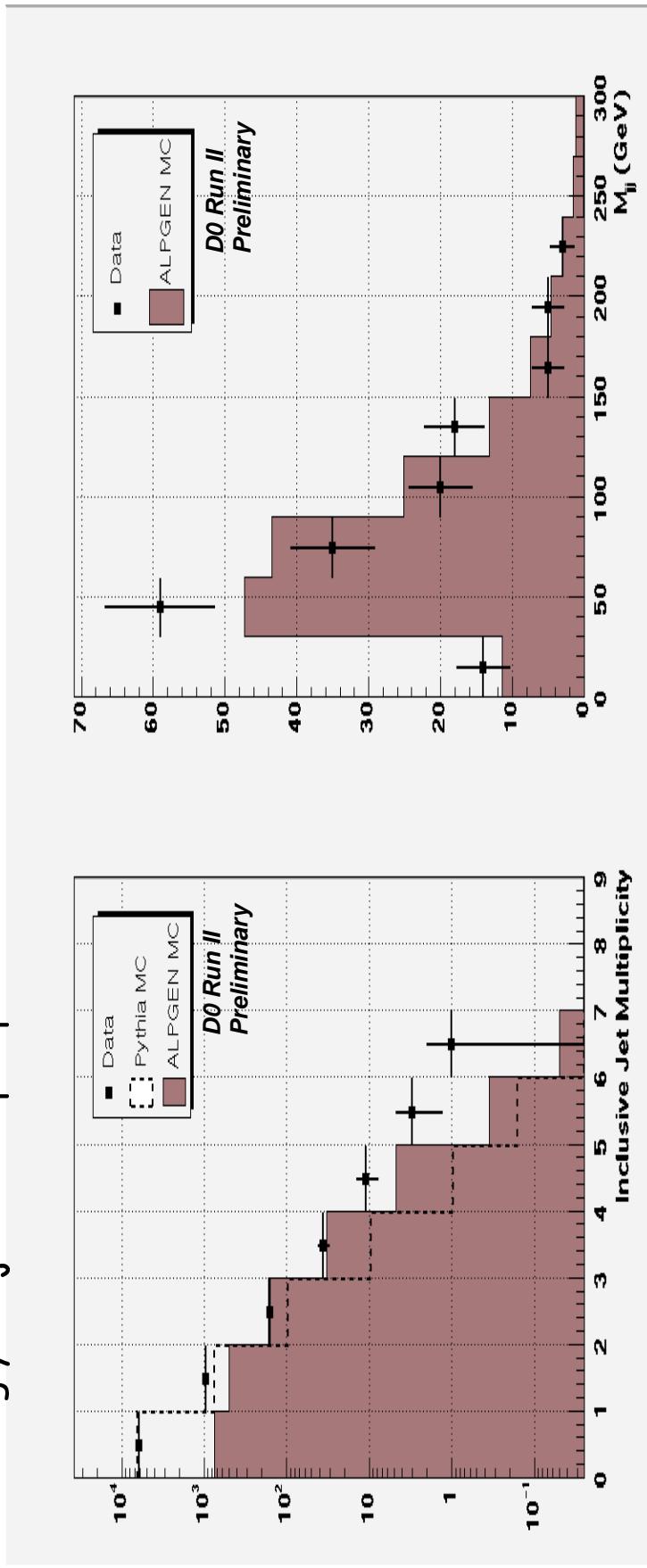


- Transverse momentum and Rapidity distributions for the reconstructed Z Boson

# Jet Properties in $Z \rightarrow e^+e^-$ Events

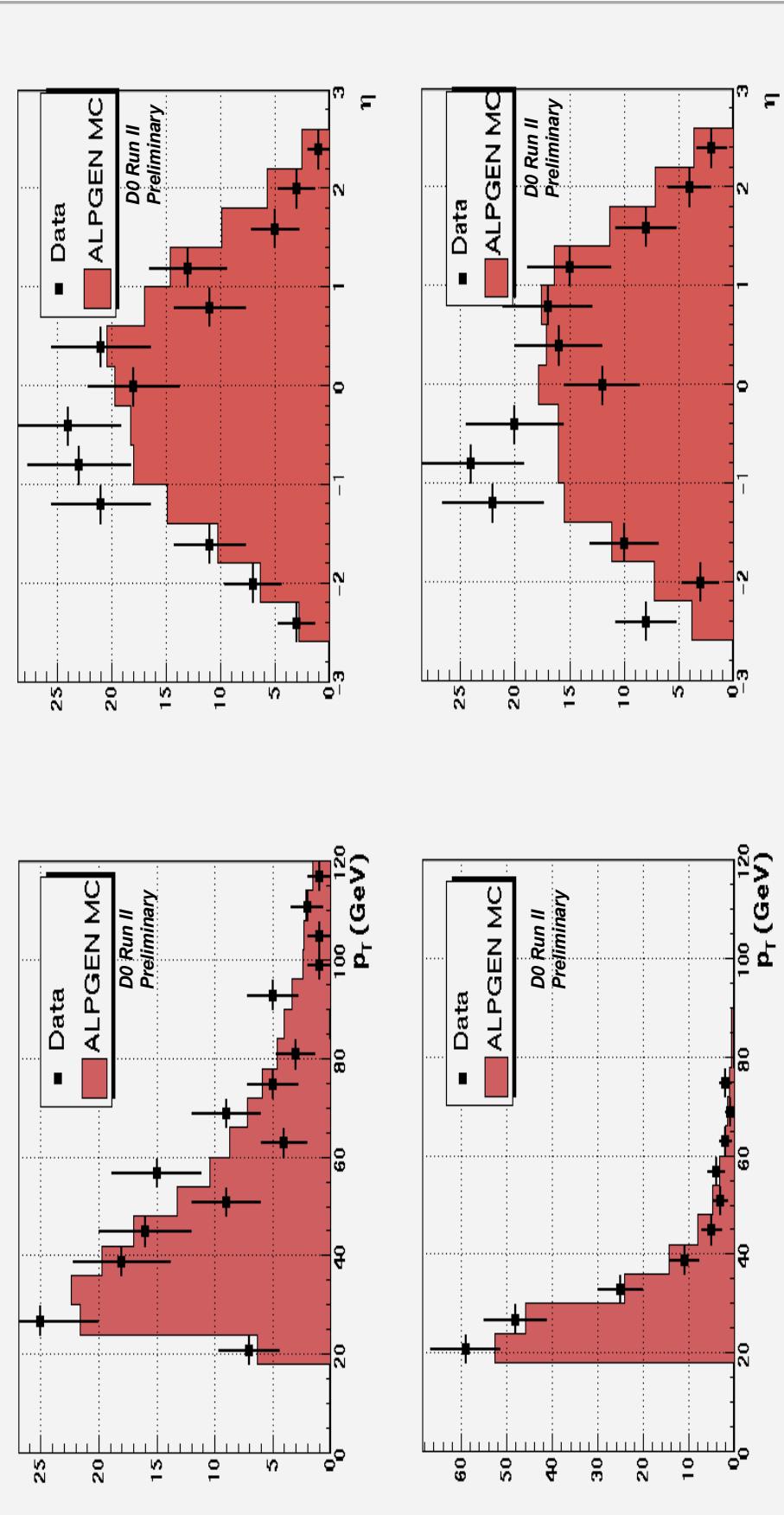


- Dots represent data - histograms represent ALPGEN/Pythia MC & GEANT detector simulation
  - Pythia only good for LO
  - Need ALPGEN (matrix element event generator) for NLO processes
- Get roughly 1 dijet event per pb<sup>-1</sup>!



- Inclusive Jet Multiplicity and Dijet invariant mass distribution

# Jet Properties in $Z \rightarrow e^+e^-$ Events (contd)



- Transverse momentum and  $\eta$  distributions for leading and second leading jet in  $Z$  events

# Summary



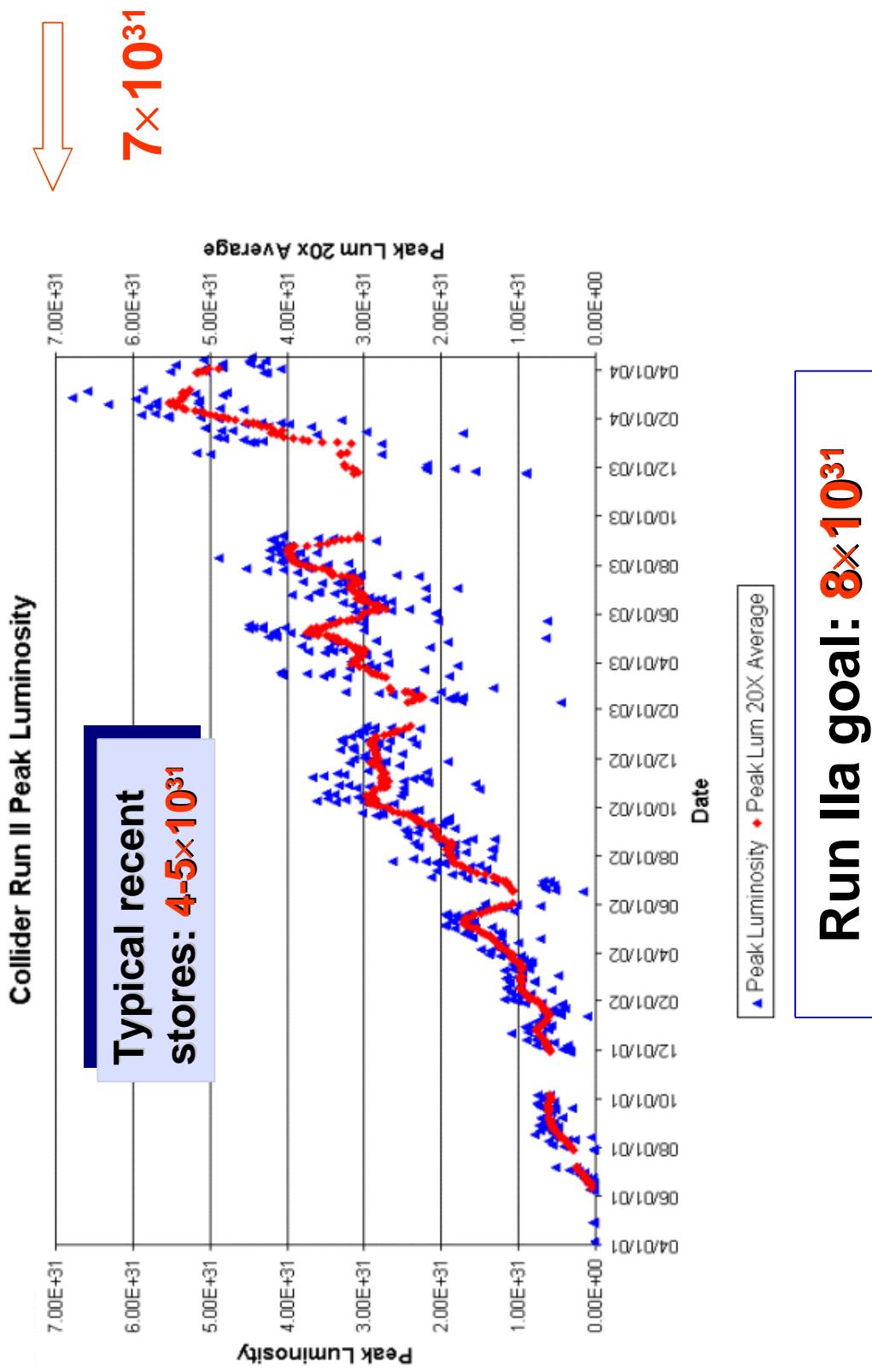
- Properties of  $Z(\rightarrow e^+e^-) + \text{Jets}$  events have been studies as a first step towards Higgs search in the  $ZH \rightarrow e^+e^-bb$  channel
- Kinematic properties of events have been compared to MC simulations
- Next step: Calculation of Cross Sections vs Jet Multiplicity and comparison to theoretical predictions
- More data coming up soon
- **Higgs hunting at the Tevatron has begun !!**



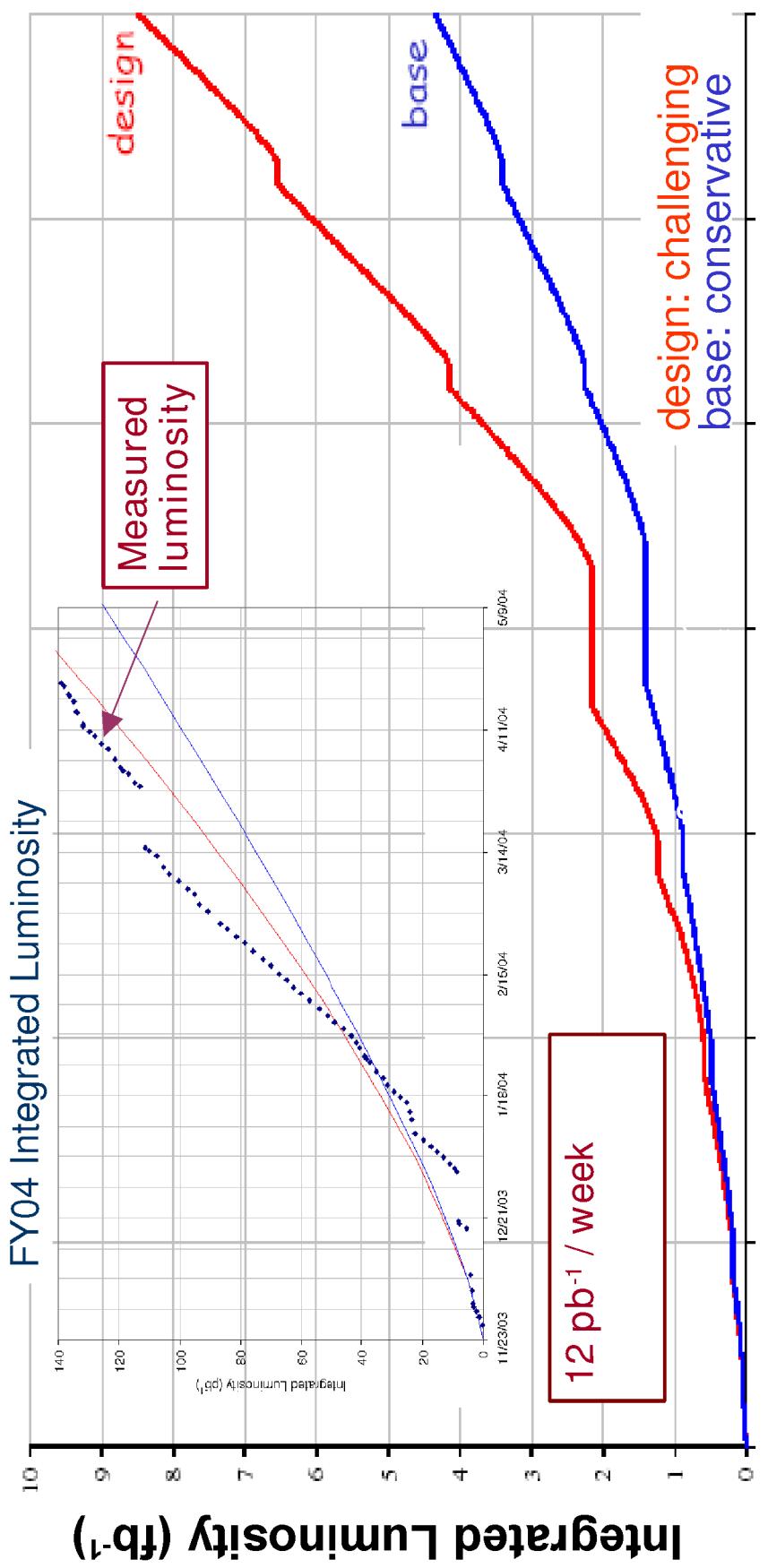
# Backup Slides ...



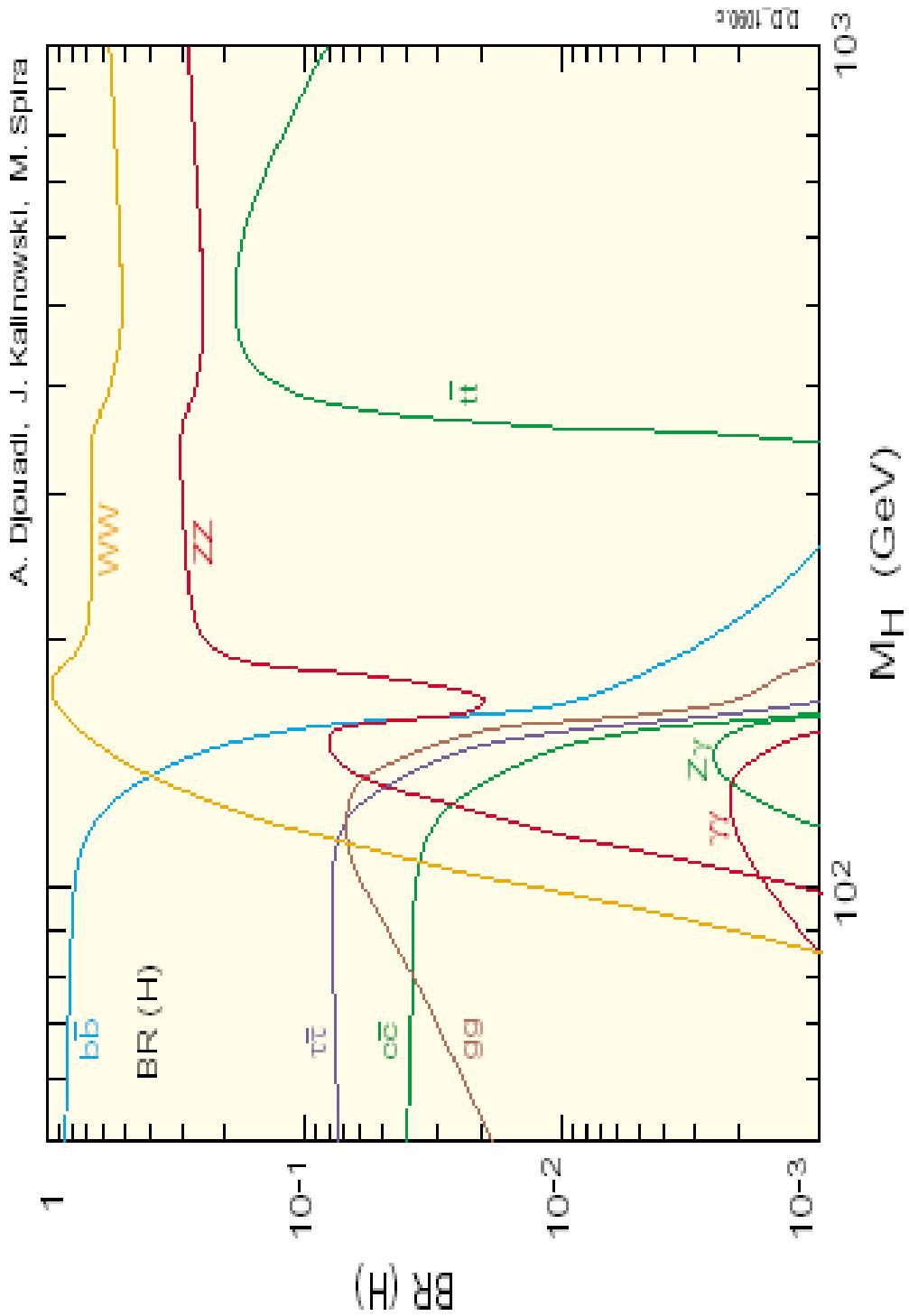
# Tevatron Peak Luminosity



# Tevatron Performance



# SM Higgs Decay Modes



# Analysis Event Selection



- Electrons:
  - EMFraction > 0.9
  - Isolation < 0.15
  - HMatrix7 < 12.0
  - p<sub>T</sub> > 20.0 GeV
  - $|\eta_{\text{det}}| < 1.1$
- Jets:
  - 0.05 < EMFraction < 0.95
  - CHFraction < 0.4
  - HotFraction < 10.0
  - N90 > 1
  - L1 confirmation
  - Removing jets overlapping with EM objects with  $\Delta R$  of 0.4
  - JES corrected p<sub>T</sub> > 20 GeV
  - At least one trackmatched object (based on  $\chi^2$  of the trackmatch based on E/p and the matching distance)
  - 80 GeV < m<sub>ee</sub> < 100 GeV